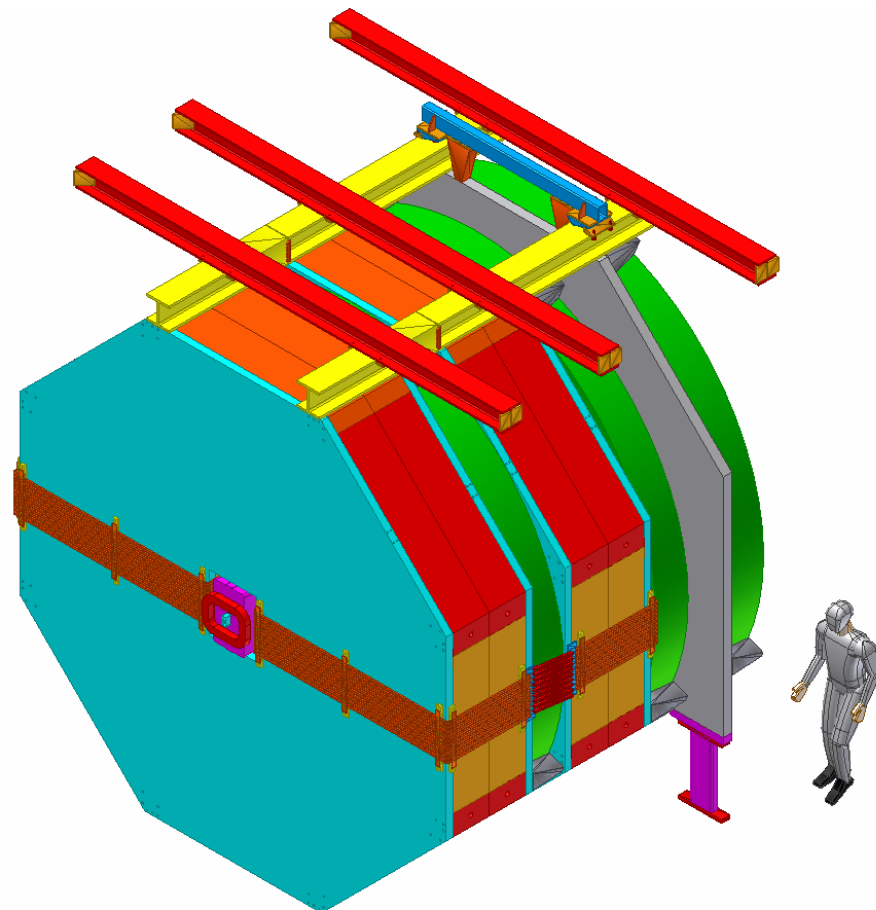
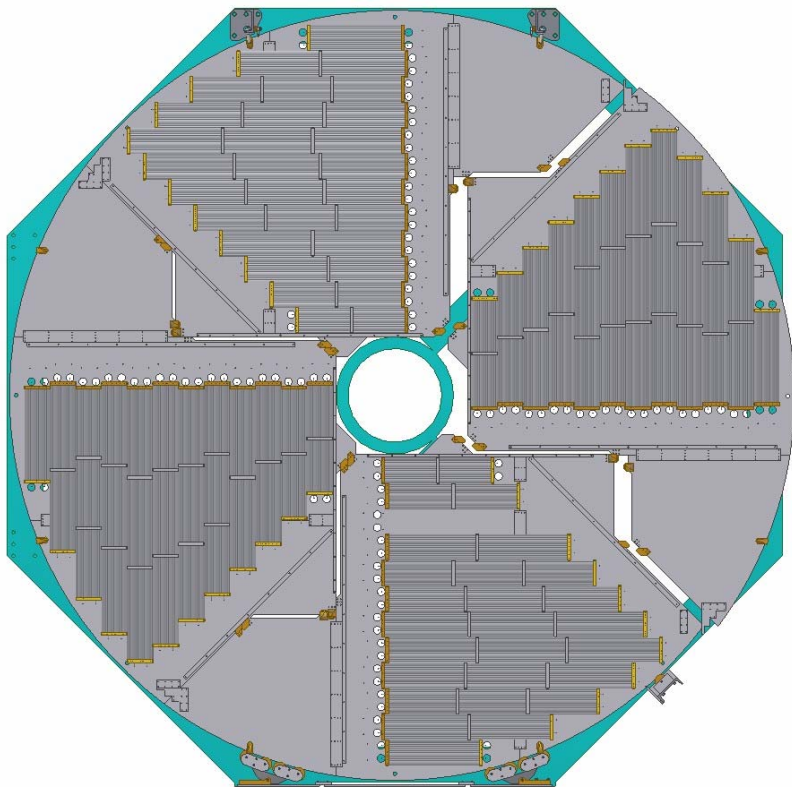




# BTeV Muon (WBS 1.5)

Paul Sheldon ~ Vanderbilt University



■ **Illinois**

- Mats Selen
- Jim Wiss
- **Doris Kim**
- Mike Haney
- Vaidas Simaitas

**Legend:**

Engineer  
Faculty  
**PostDoc**  
Technical

■ **Pavia**

- Gianluigi Boca

■ **Puerto Rico**

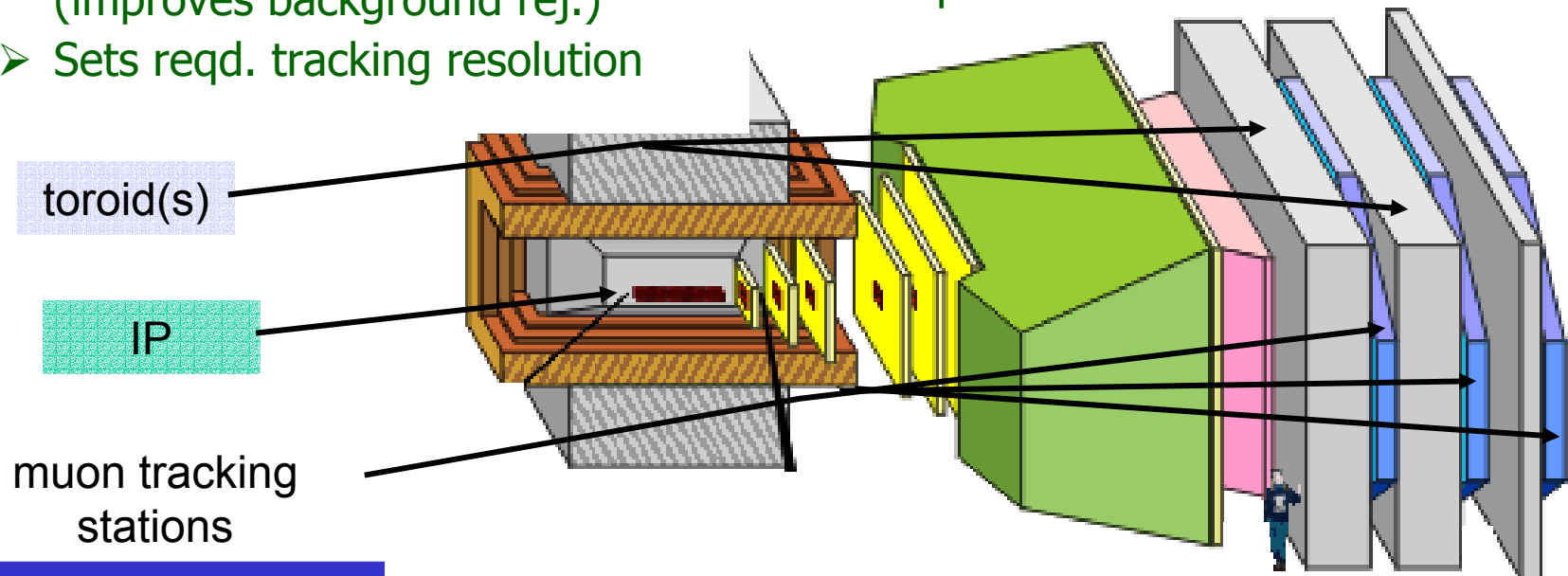
- Angel Lopez
- Hector Mendez
- Eduardo Ramirez
- **Zhong Chao Li**
- Aldo Acosta

■ **Vanderbilt**

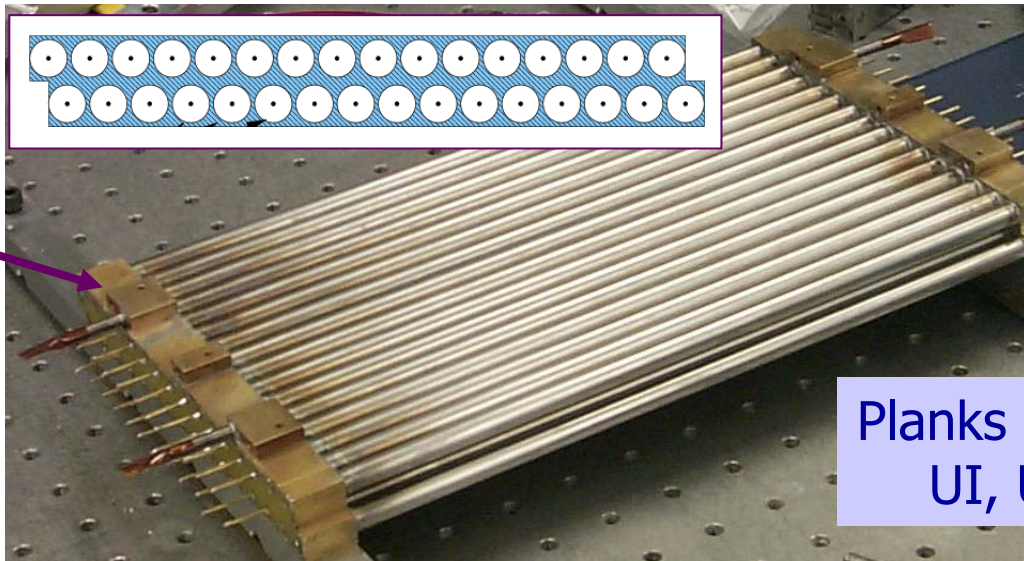
- Will Johns
- Paul Sheldon
- Med Webster
- **Eric Vaandering**
- John Fellenstein



- Provides Muon ID and Trigger
  - Trigger & ID for interesting physics states
  - Check/debug pixel trigger
- Fine-Grained tracking + toroids
  - Stand-alone mom./mass trig.
  - Momentum “confirmation” (improves background rej.)
  - Sets reqd. tracking resolution
- Other design goals/constraints:
  - Min. pattern recognition confusion
  - Minimize occupancy
  - Distribute occupancy uniformly
  - Minimize max. drift time
  - Robust, high-rate detector element
  - Size of hall limits wide-angle acceptance to 200 mrad

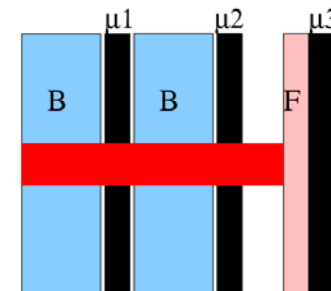


- Basic Building Block: Proportional Tube “Planks”
  - 3/8” diameter Stainless steel tubes (0.01” walls)
  - “picket fence” design
  - 30 $\mu$  (diameter) gold-plated tungsten wire
  - Brass gas manifolds at each end (RF shielding important!)
  - Front-end electronics: use Penn ASDQ chips, modified CDF COT card
  - Likely to use 85% Ar - 15% CO<sub>2</sub> (no CF<sub>4</sub>... more on this later)



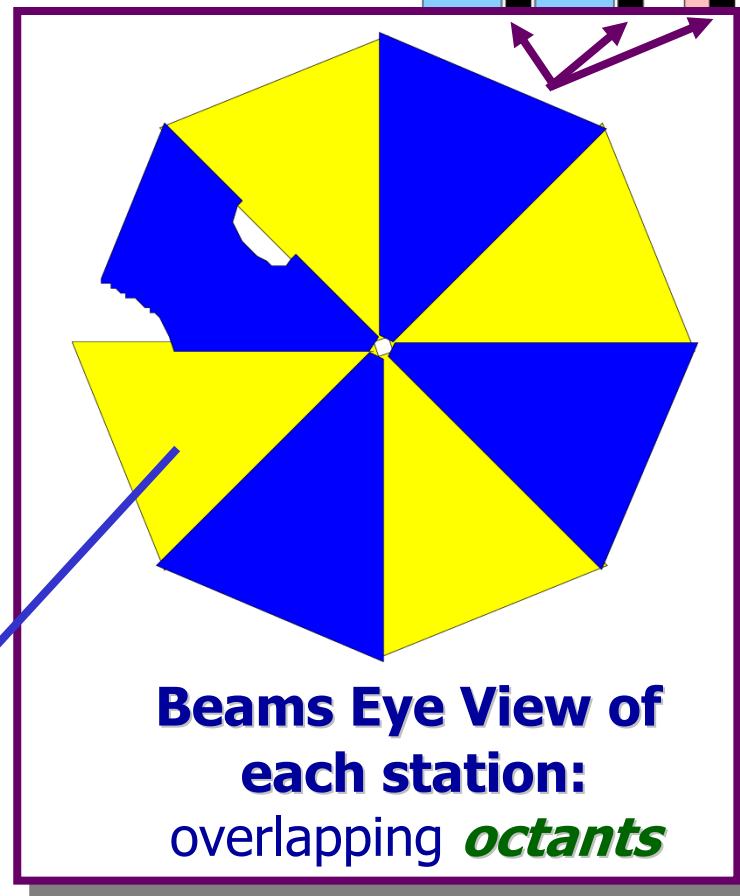
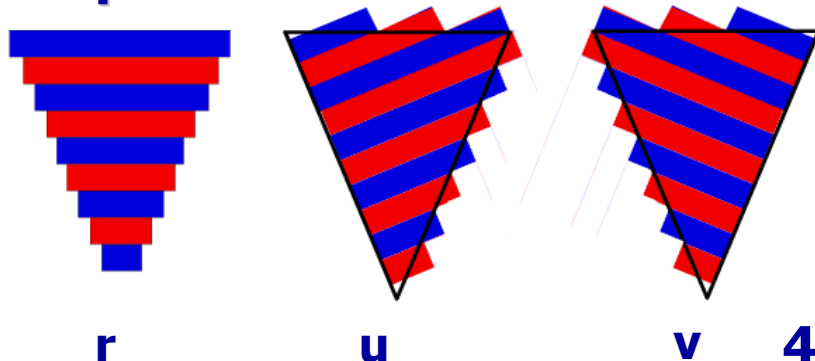
Planks will be built at  
UI, UPR, & Vand.





- Meets design goals/constraints:
  - Min. pattern recognition confusion
  - Reduce occupancy
  - Distribute occupancy uniformly
  - Minimize max. drift time
  - Robust, high-rate detector element
  - Stand-alone momentum/mass trigger
  - Momentum "confirmation" (improves background rejection)
  - Meets reqd. tracking resolution (<2mm)

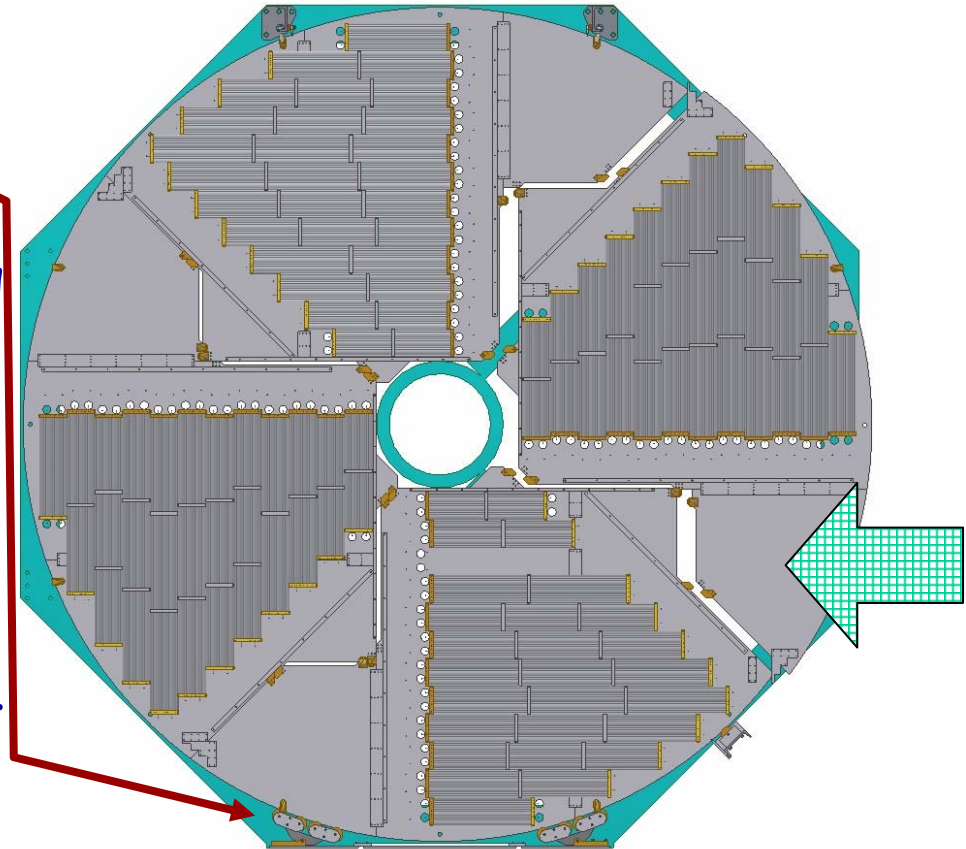
**12 planks "cover" each octant**



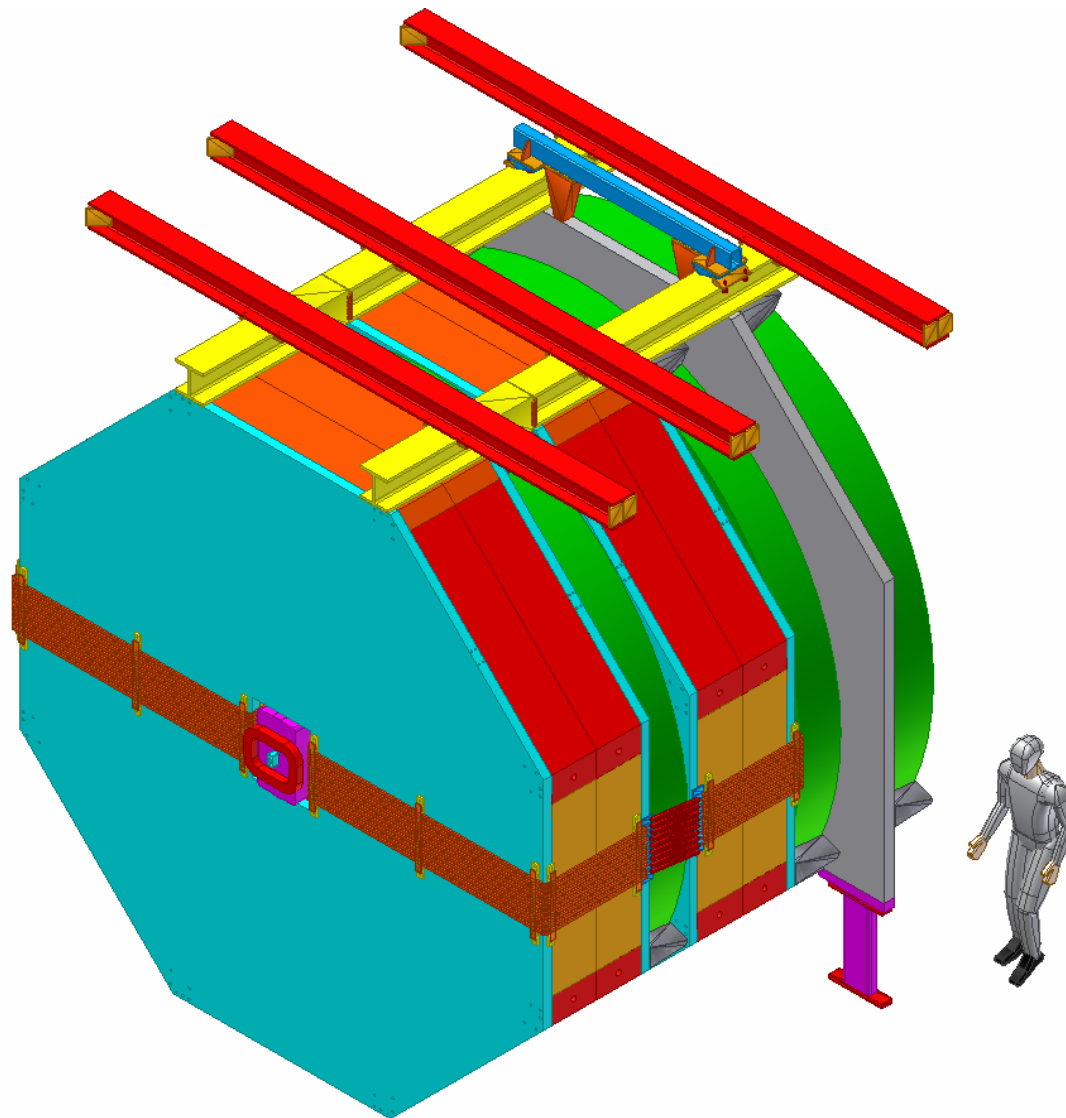
**stereo views provide  $\phi$  info.**

**4 views per station (r, u, v, r)**

- 4 *octants* make a wheel, two wheels construct a view.
- Octants will be built at institutions and delivered to FNAL.
- "Vertical Lazy Susan" installation - rotate during installation on floor rollers
- Each wheel will then be hung vertically from overhead beams.
- This allows each view to be individually serviced: it will be possible to install and/or remove an octant during run.
- Each octant is installed in wide aisle horizontally.



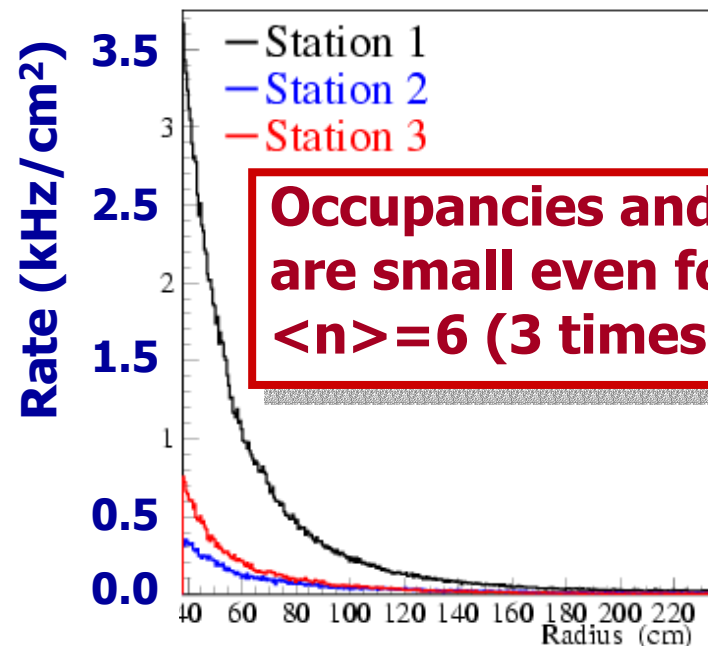
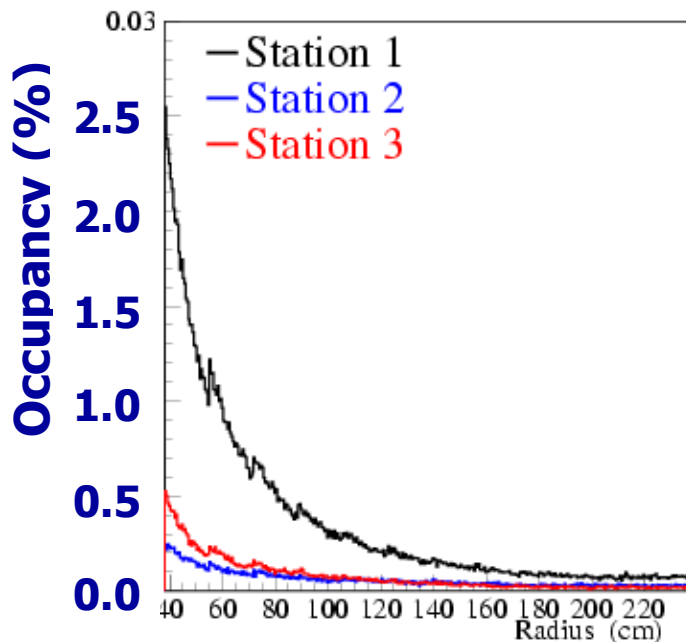
U - stereo wheel plates.



- The entire muon **system** can move with the toroid package since there are no floor connections.
- The plates are supported from individual floor rollers during installation and then hung vertically from the overhead beams.

- Minimum bias events will be largest source of hits in detector
- Generated assuming an average of 2 interactions/crossing
  - OLD Luminosity of  $2 \times 10^{32}$  and 132 ns bunch spacing

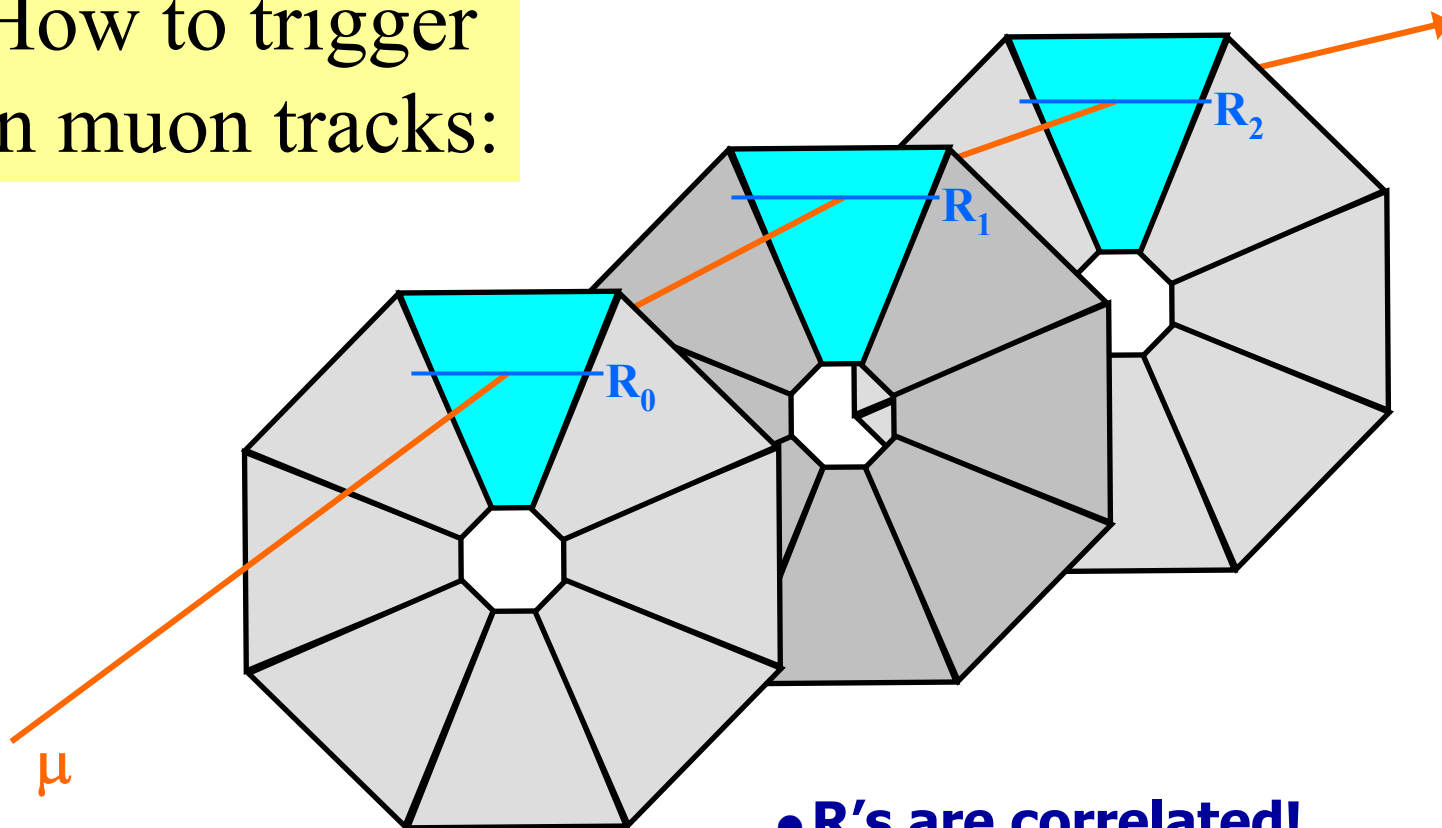
What	Station 1	Station 2	Station 3	Total
avg. # of hits per crossing	42	8	9	54
avg. occupancy	0.34%	0.06%	0.07%	0.15%
max. channel occupancy	2.50%	0.24%	0.52%	
max. channel rate (kHz/cm <sup>2</sup> )	3.7	0.4	0.8	



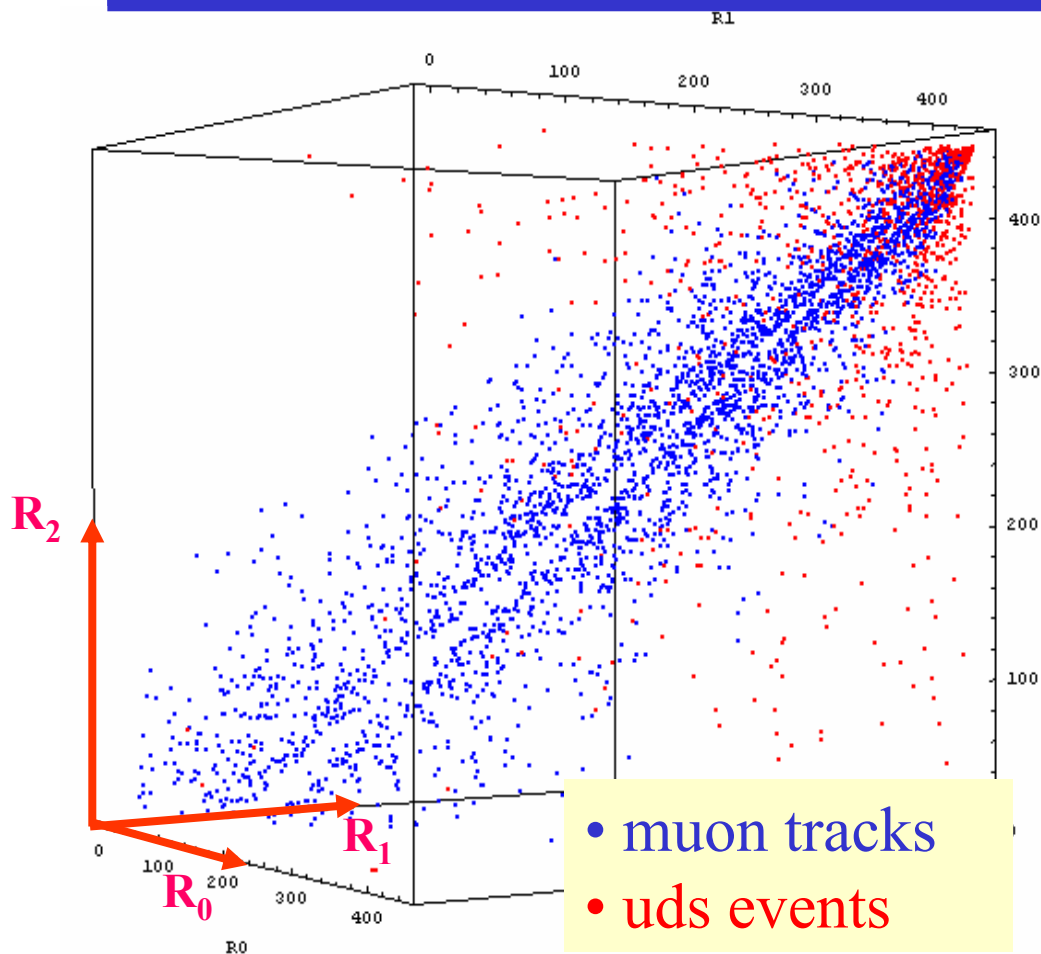
**Occupancies and rates are small even for 396ns  
<n>=6 (3 times larger)**



How to trigger  
on muon tracks:



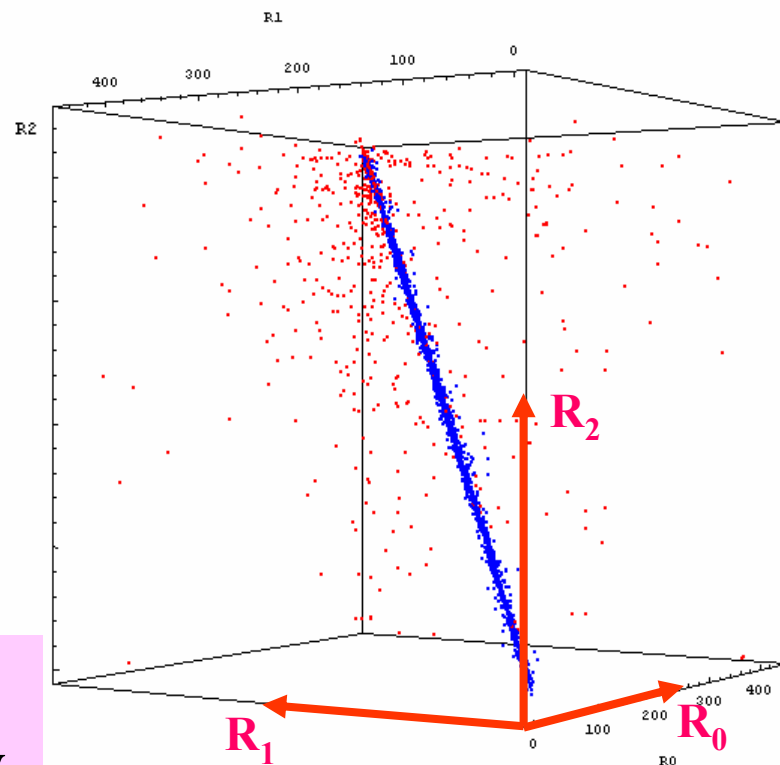
- **R's are correlated!**
- The same is true for ***U***, ***V*** views...



Muon tracks line on a simple plane:

$$R_2 = 27.69 - 1.26 \cdot R_0 + 2.20 \cdot R_1$$

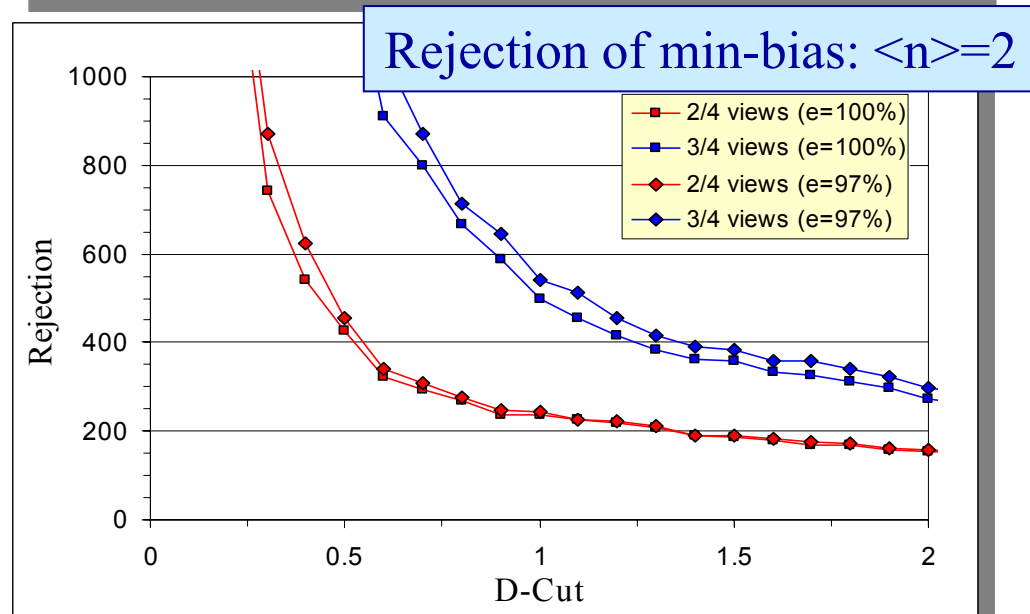
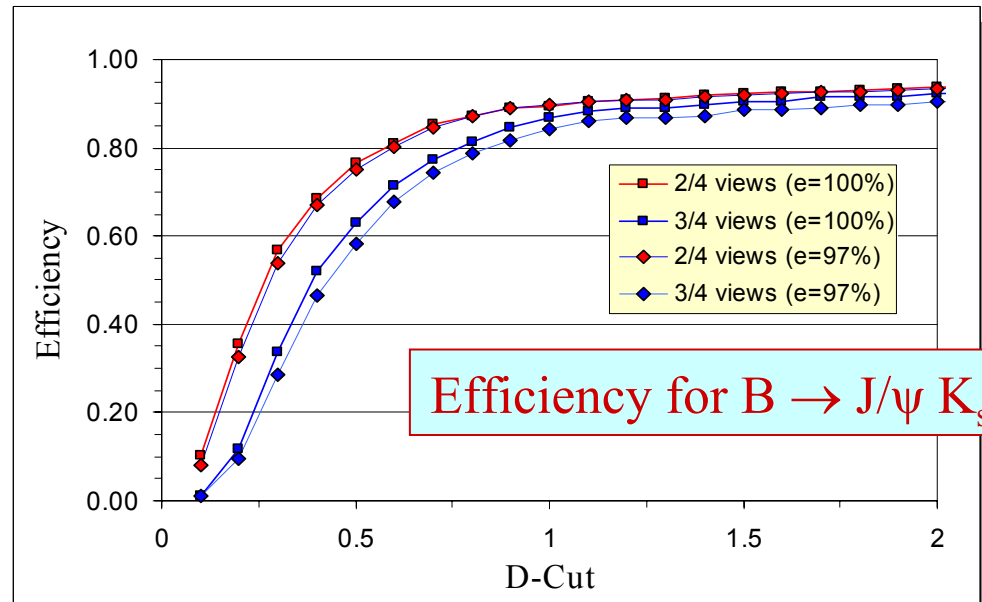
( $R_0, R_1, R_2$ ) in raw “tube numbers”



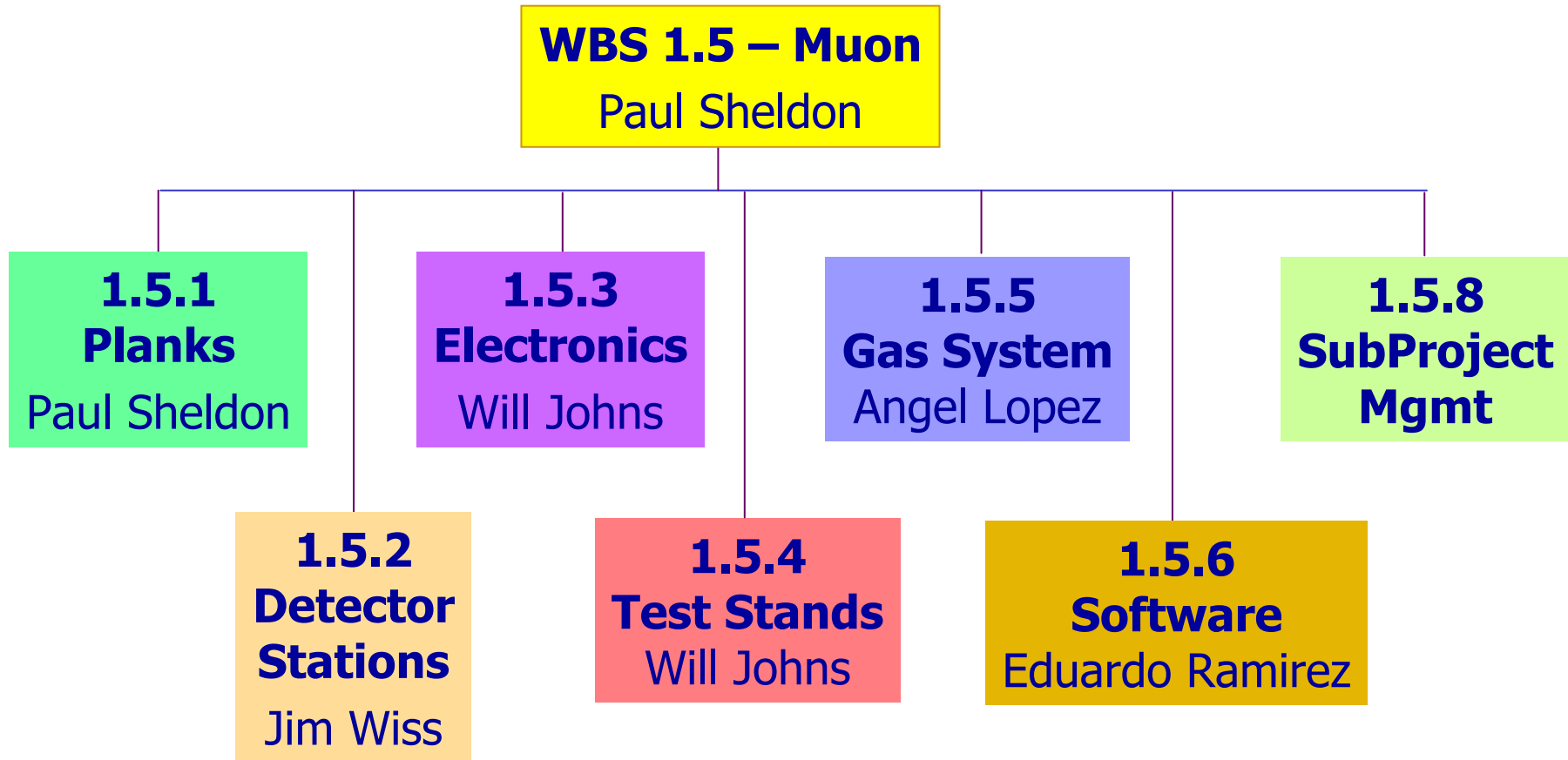
**Strategy:** Cut on closest distance to this plane for each crossing/octant/view.

## BTeV GEANT Study

- D-cut: max. distance muon cand. can be out of plane
- Can also use "R" cut (ignore inner radii of system)
- >80% efficiency with rejection of >500
- What if backgrounds are worse? Try  $\langle n \rangle = 3, 4, 5$
- Even with  $\langle n \rangle = 5$ , can still get ~60% efficiency with rejection of 500
- **Mass cut possible:** not studied yet but is among several possible improvements

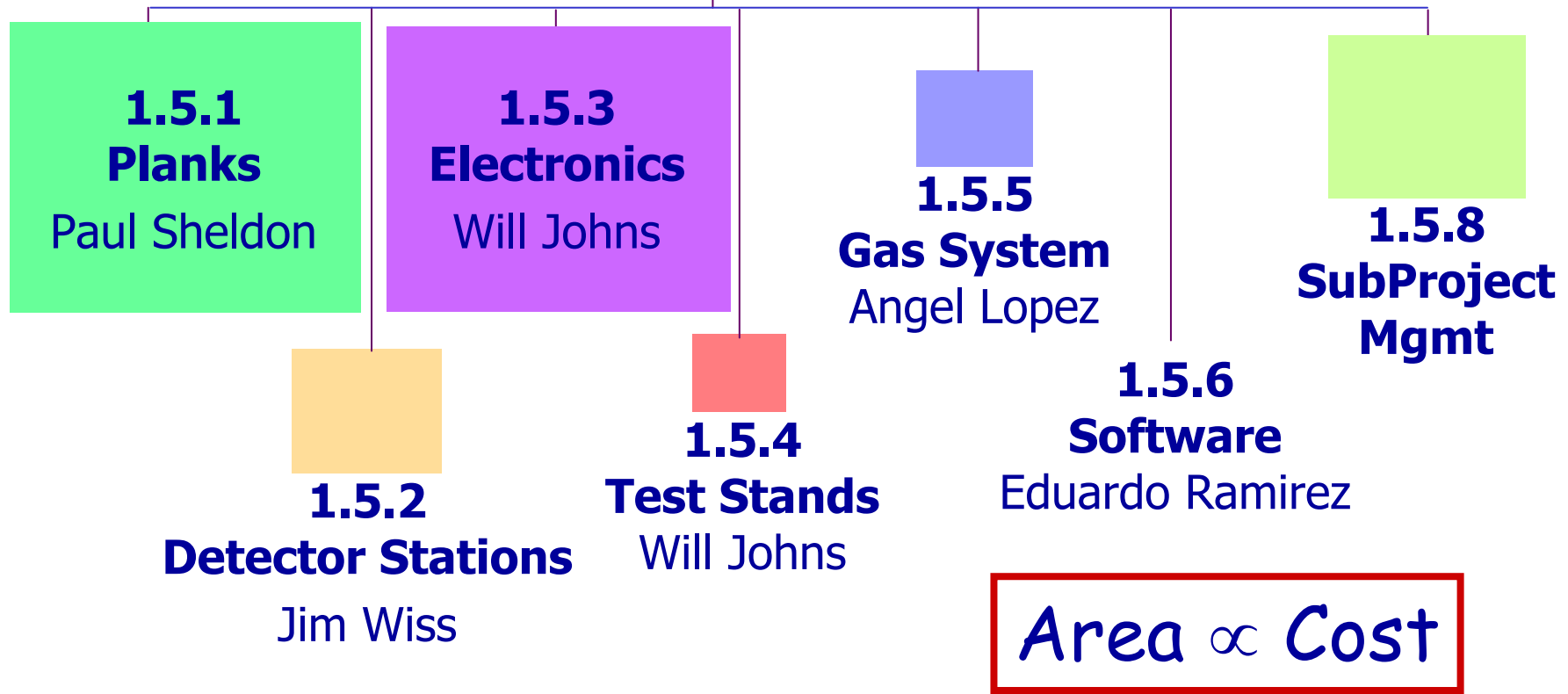


Base cost: \$3.81M (Material: \$2.93M, Labor: \$0.88M)



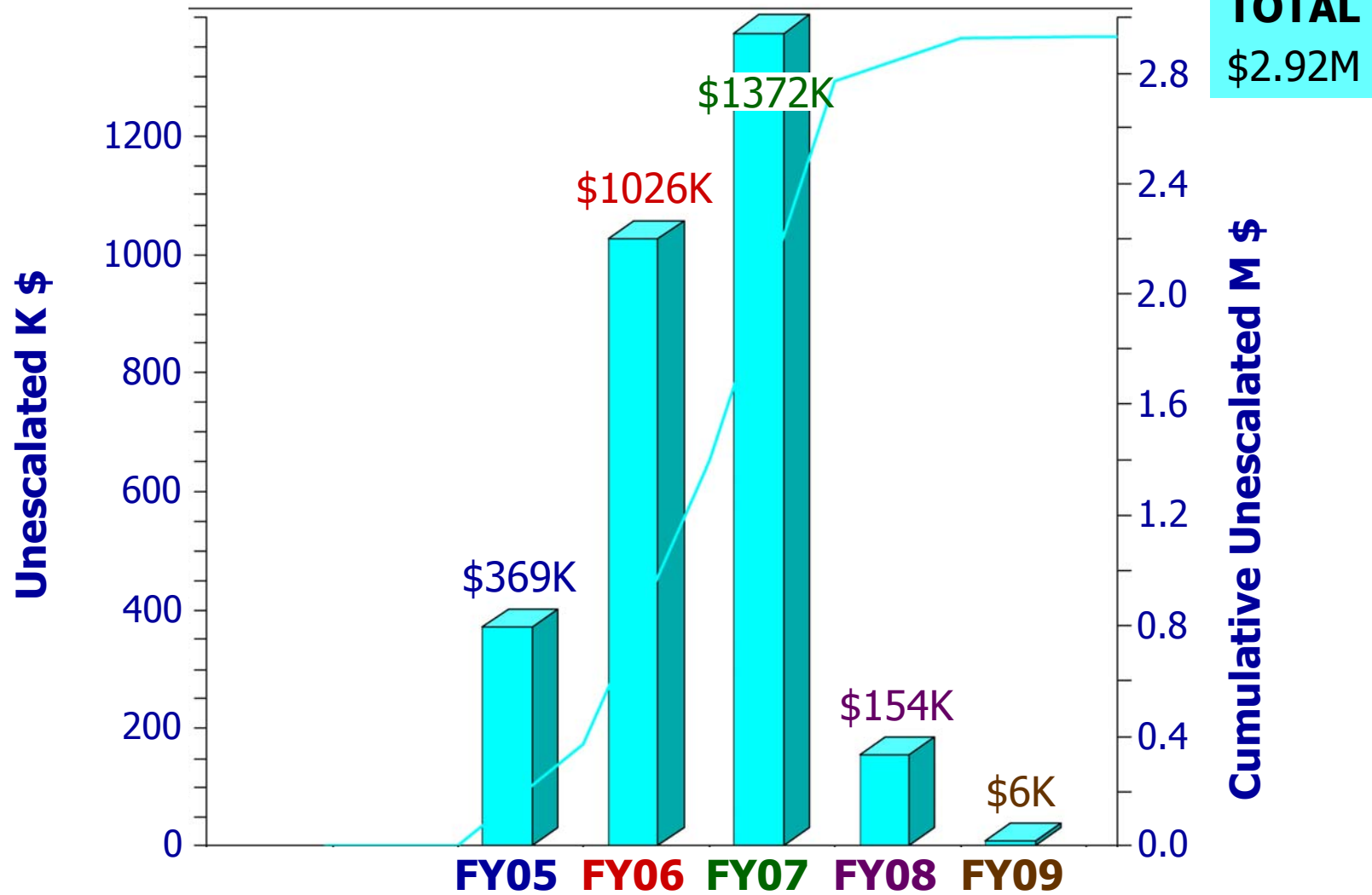
Base cost: \$3.81M (Material: \$2.93M, Labor: \$0.88M)

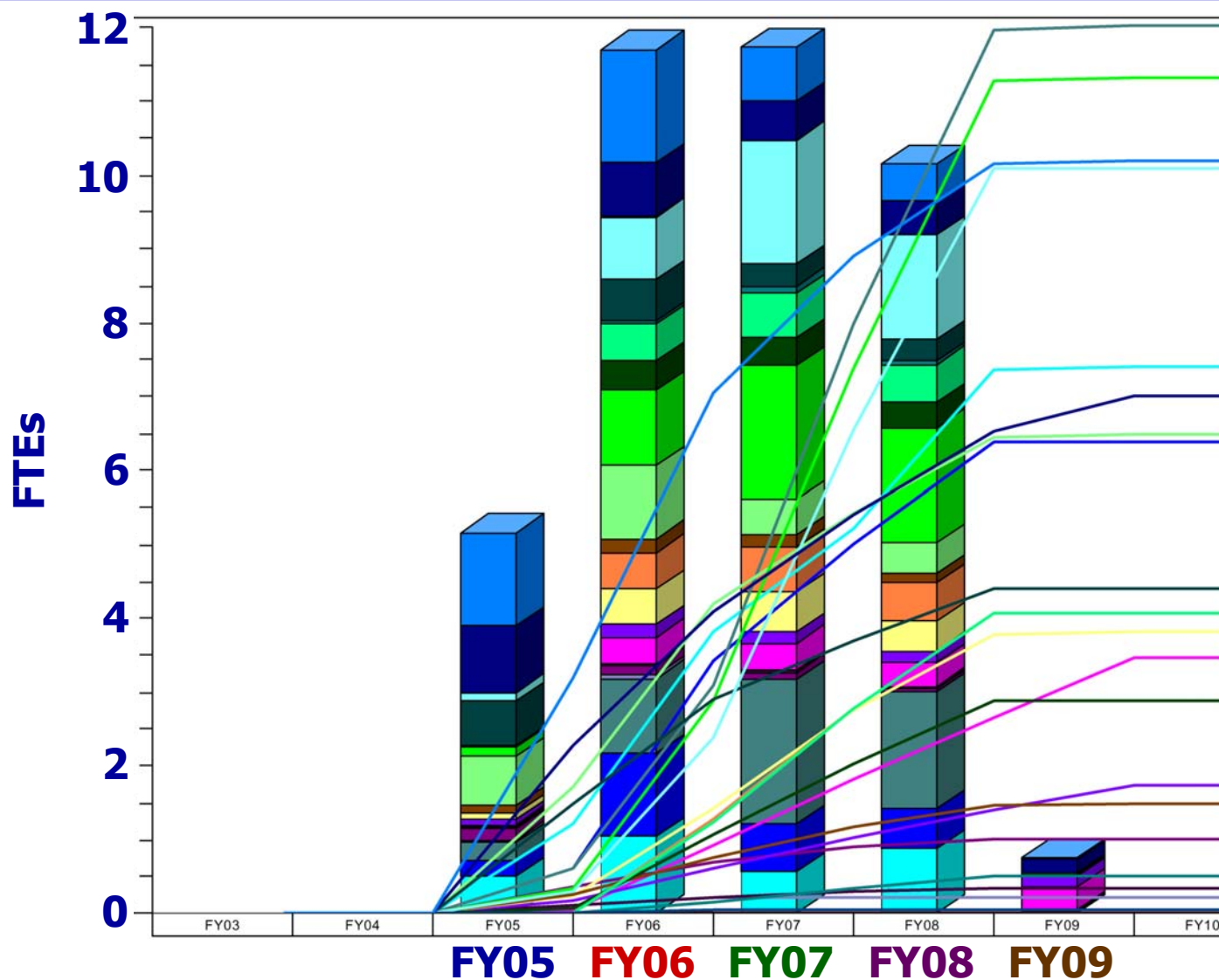
**WBS 1.5 – Muon**  
Paul Sheldon

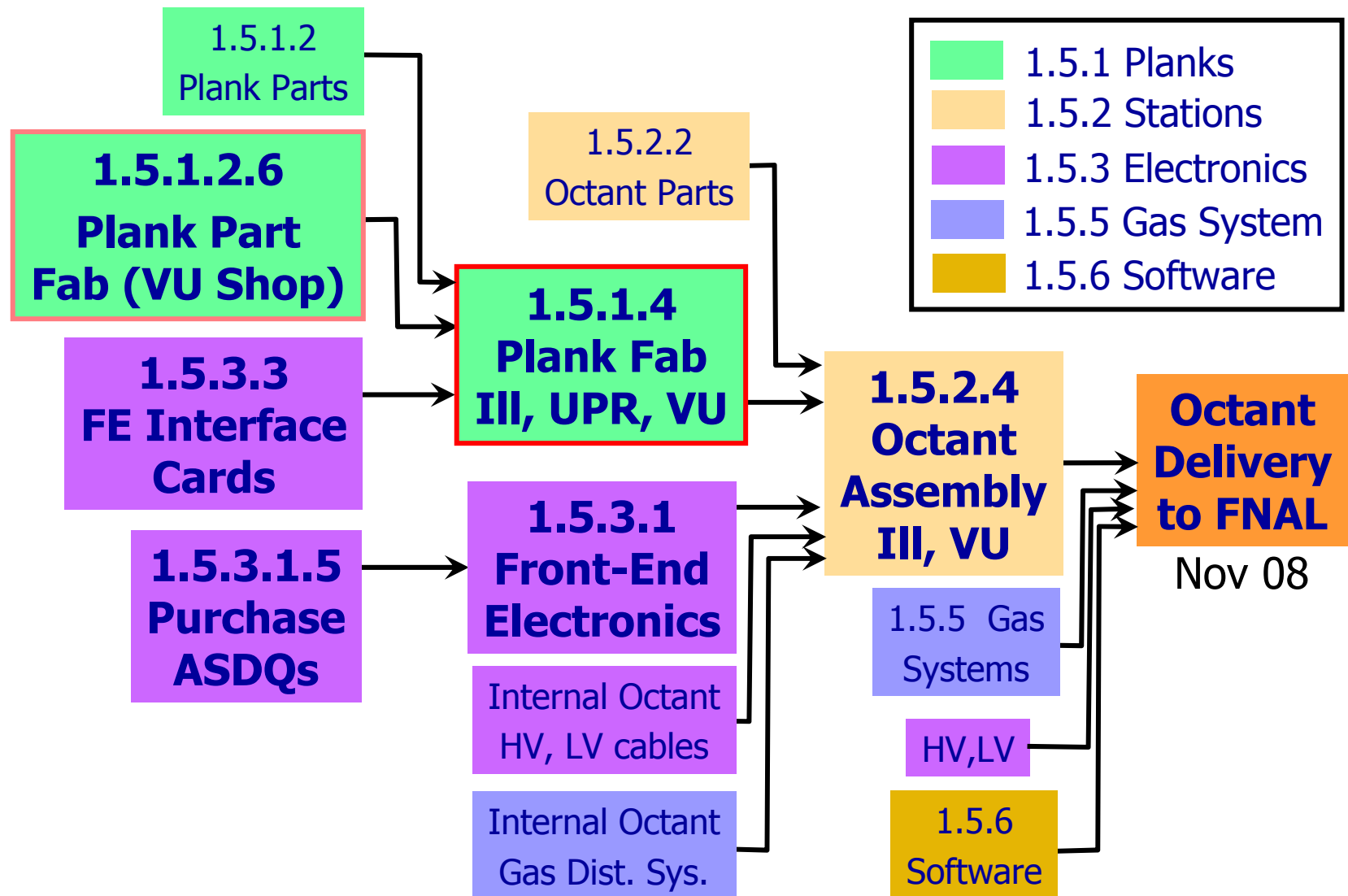


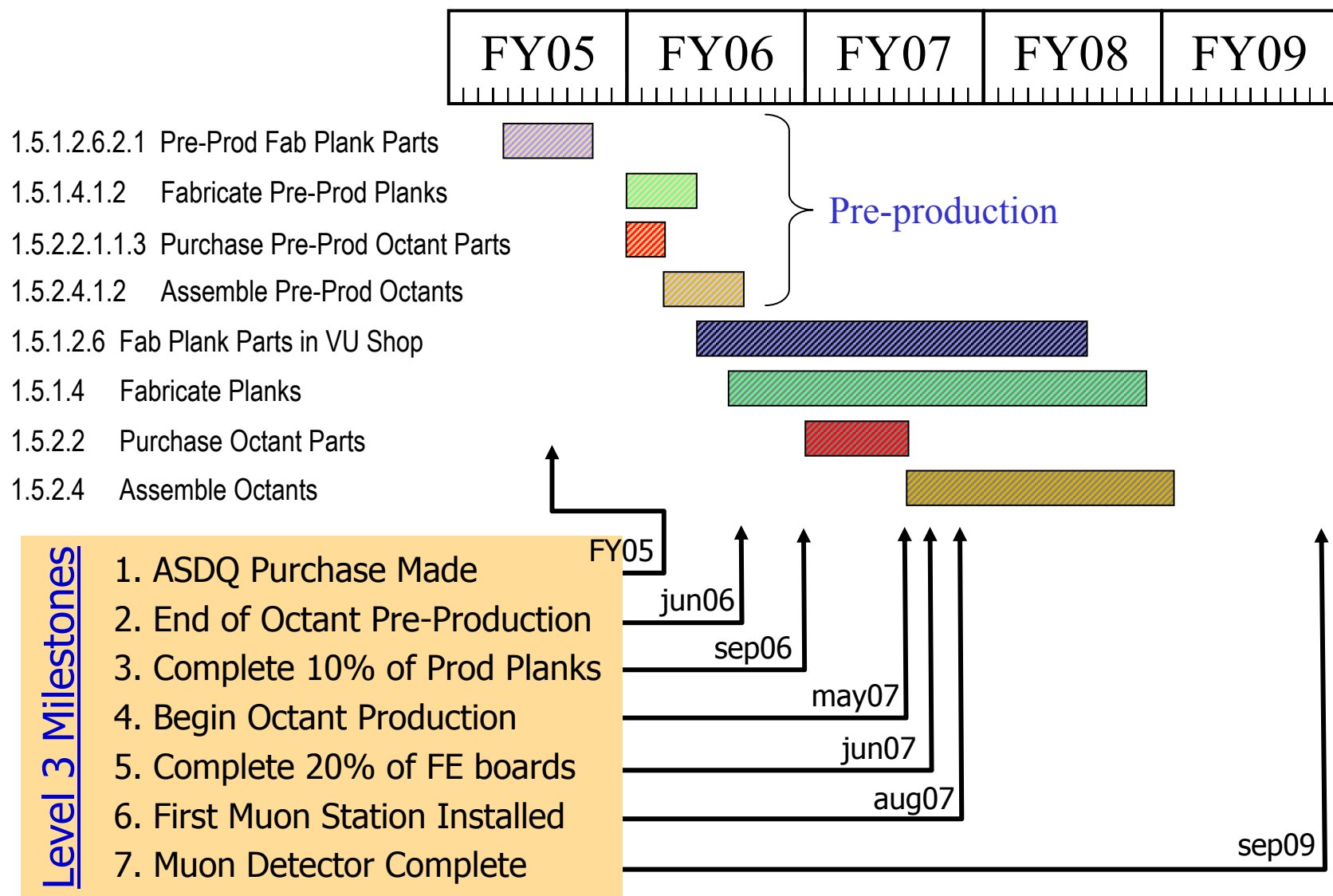


Activity ID	Activity Name	Base Cost (\$)	Material Contingency (%)	Labor Contingency (%)	Total FY05	Total FY06	Total FY07	Total FY08	Total FY09	Total FY05-09
<a href="#">1.5.1</a>	Muon Detector Planks	1,477,616	43	35	215,500	776,002	856,567	243,129	0	2,091,198
<a href="#">1.5.2</a>	Muon Detector Stations	277,504	40	35	1,783	64,534	308,942	10,774	1,718	387,751
<a href="#">1.5.3</a>	Muon Detector Electronics	1,343,612	29	17	299,816	423,494	883,071	106,076	0	1,712,458
<a href="#">1.5.4</a>	Muon Detector Test Stands	108,246	50	50	0	162,370	0	0	0	162,370
<a href="#">1.5.5</a>	Muon Detector Gas System	148,295	50	31	0	210,950	2,466	0	0	213,416
<a href="#">1.5.6</a>	Muon Detector Software	0	0	0	0	0	0	0	0	0
<a href="#">1.5.8</a>	Muon Detector Subproj Mgmt	455,167	31	25	59,729	150,291	149,589	123,855	90,636	574,100
<b>1.5</b>	<b>Subproject 1.5</b>	<b>3,810,441</b>	<b>37</b>	<b>28</b>	<b>576,829</b>	<b>1,787,641</b>	<b>2,200,635</b>	<b>483,834</b>	<b>92,353</b>	<b>5,141,292</b>











WBS item	Risk Event	Response/mitigation strategy
1.5.2.2.3.4.1	ASDQ manufacturing process goes away	Attempt to purchase chips early and package later. Until purchased, obtain constant updates on status to minimize schedule slip. Migrate ASDQ design to newer process. Latest update (10/03) is that process is in heavy use by automated test equipment industry and not expected to disappear in the the next couple of years. We have therefore lowered the risk from high (0.5) to moderate (0.3) and will continually update this risk until purchase is made. (Funds for possible migration to newer process are located in Straw detector.)
1.5.1.2	Plank construction takes much longer than expected	Use early pre-production run to obtain more accurate estimates. This allows a long time to make up potential schedule slippages.

- We have significant experience w/ many of the steps necessary to build and install the muon system
  - Built roughly 2 dozen planks, *with student labor*
  - Designed, built and used many of the test stands that we will use in our quality assurance program (tension measurement, etc.)
  - Built a 1/5 scale model of our full detector (including the toroids), using it to investigate support and installation issues
  - During the past year, significant engineering on mechanical support structure, now have a well-developed design
  - We have a well-developed design for the Front-End electronics and we have verified its properties with prototypes

## Tension Test Stand

File Settings Help

Single Tube Plank

Plank Barcode: 2010000100073 Enter Clear

Decoded Barcode: 2010000100073

Station: VU Tension Assembler: Eric Vaandering

Plank Length

☐ 30 cm ☐ 45 cm ☐ 60 cm ☐ 75 cm ☐ 90 cm ☐ 105 cm  
☐ 120 cm ☐ 135 cm ☐ 150 cm ☐ 165 cm ☐ 180 cm ☐ 195 cm

Tube Number: 8

Central frequency [Hz]: 500

Calibrate Measure Tension Help

Ready to Measure

Accept Measurem

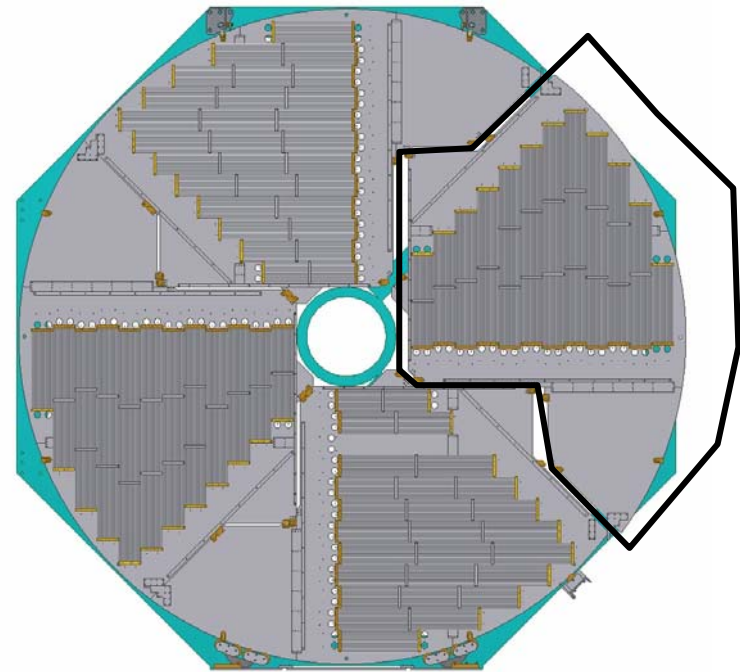
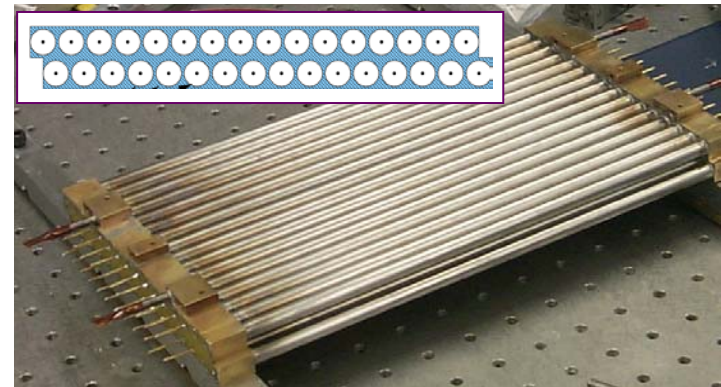
400 59

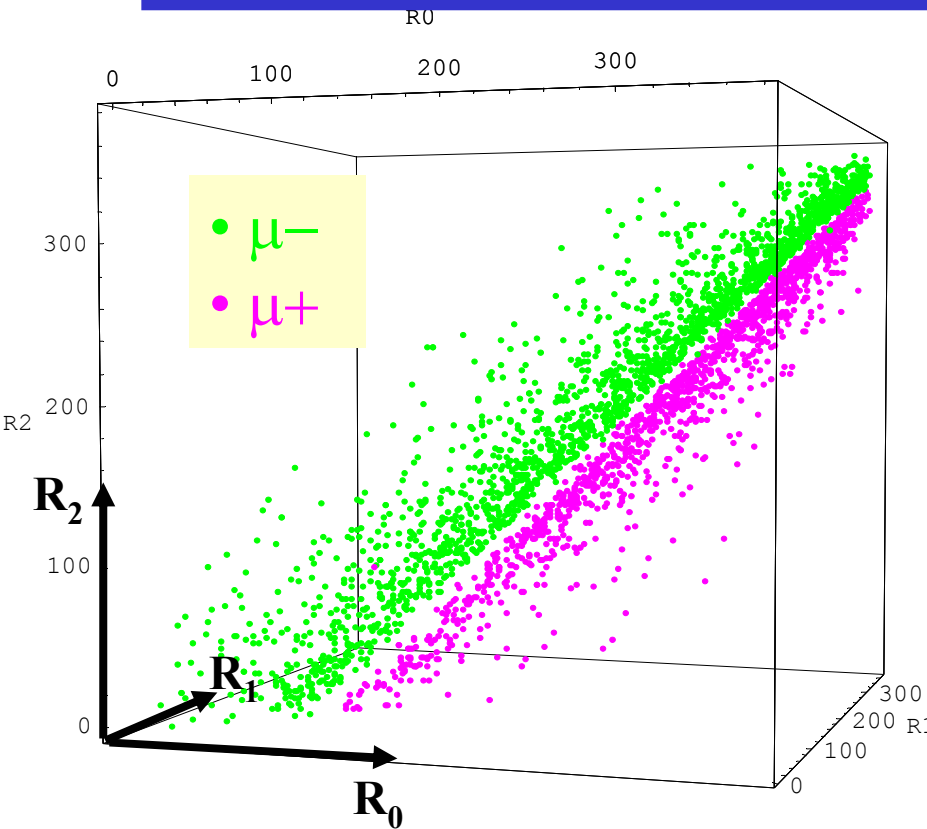
Accept Reject

Barcode  
tracking  
system

- We have dealt with many of the vendors we will use
  - Vanderbilt shop has fabricated the parts it has to make
  - Stainless tube vendors, ...
  - Penn ASDQ's
- **The labor required is modest (43 FTEs) and well-matched to the size of the research groups already on-board.**
  - Physicist (“off-project”) labor reqd is already present in our groups
  - student labor required is not larger than is typically present in each of our groups
- **We have chosen a robust, easy to build, well understood detector technology and our studies indicate that it is well matched to our problem.**
  - This includes a well-developed and engineered design for the mechanical structure and support

- **Plank**: basic building block of the system. A double layer of 32 proportional tubes, offset in a “picket fence” arrangement.
- **Quad** or **Octant**: the basic installation unit of the system. We use both words interchangeably: they used to refer to different objects but as the design matured they became the same thing. 4 Quads make a wheel, two wheels give full coverage in  $\phi$ .





Determining track charge is simple !

All we need to  
do is look at  $R_2$  vs  $R_0$ .

